SCHOOL OF
CIVIL ENGINEERING

INDIANA
DEPARTMENT OF TRANSPORTATION

JOINT HIGHWAY RESEARCH PROJECT

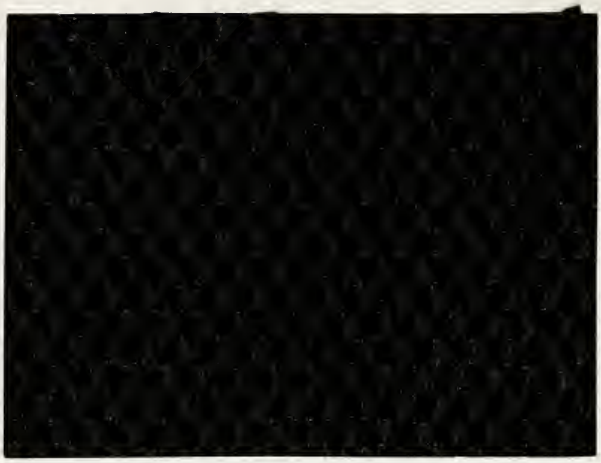
FHWA/IN/JHRP-89/4

Final Report

1988 UPDATE OF THE INDIANA HIGHWAY COST-ALLOCATION STUDY

K. C. Sinha
S. K. Saha
T. F. Fwa
A. B. Tee
H. L. Michael

PURDUE UNIVERSITY



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FINAL REPORT

TO: H. L. Michael, Director
Joint Highway Research Project

March 1, 1989

Project No: C-36-54SS

FROM: Kumares C. Sinha, Research Engineer
Joint Highway Research Project

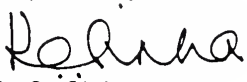
File: 3-3-45

Attached is the Draft Final Report on the HPR Part I Study titled, "1988 Update of the Indiana Highway Cost-Allocation Study." This report presents the findings of the updated study for Indiana and it has been prepared under the direction of Professor K. C. Sinha.

The findings indicate that the subsidization of heavy commerical vehicles by passenger cars and light weight single unit trucks, revealed in the 1983-84 Cost Allocation Study, is thus still continued, even though the revenue/cost ratio for combination trucks was somewhat better in 1988 than what it was in 1983.

This report is forwarded for review, comment and acceptance by the IDOH and FHWA as fulfillment of the objectives of the study.

Respectfully submitted,



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16. Abstract

This draft final report presents the findings of the 1988 update of the highway cost-allocation study in Indiana. The update study was based primarily on the methodology used in the 1983-84 study. The findings indicated that a significant imbalance still exists between cost responsibility and revenue contribution by different vehicle classes. The study results also showed a significant imbalance of cost responsibility among vehicle subgroups within a particular class. As a whole, the subsidization of heavy commercial vehicles by passenger cars and light weight single unit trucks, revealed in the 1983-84 cost allocation study, is thus still continued, even though the revenue/cost ratio for combination trucks was somewhat better in 1988 than what it was in 1983.

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1988 UPDATE OF THE INDIANA HIGHWAY COST-ALLOCATION STUDY

FINAL REPORT

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Engineering Experiment Station
Purdue University

in cooperation with the

Indiana Department of Highways

and the

U.S. Department of Transportation
Federal Highway Administration

March 1, 1989

ACKNOWLEDGMENTS

The preparation of this report was financially supported by Indiana Department of Highways and the Federal Highway Administration. The study was conducted by the Joint Highway Research Project of Purdue University in cooperation with the Indiana Department of Highways (IDOH). The principal investigator of the study was Kumares C. Sinha. Ron Sobecki of the IDOH Planning and Budget Division served as the technical monitor of the study. Several individuals provided much assistance. The help of Jeff Spalding of the IDOH Planning and Budget Division in preparing cost and revenue data was essential to the completion of the study. Special appreciation is extended to John Nagle, Don Houterloot and Kirk Mangold of the IDOH Program Development Division for their assistance in gathering traffic-related information. Many students and staff members at Purdue University contributed to the study, including James Dwayne, Mike Doherty, Andrew Upfield, Amiy Varma, Zubair Ahmed, Stephen Kalanie and Paul Lombard. Acknowledgment is also extended to Mrs. Pita Pritchett and Ms. Cheryl Burroughs for typing the report.

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EXECUTIVE SUMMARY

The 1983-84 Indiana Highway Cost Allocation Study was updated to assess the effect of changed traffic composition and travel and levels of highway expenditure and revenue. The updated study estimated the expenditures for fiscal year 1988 related to highway and bridge construction, rehabilitation and maintenance of the entire highway network in Indiana including the state and local systems. The revenues contributed by various vehicle groups and users in fiscal year 1988 were also documented.

The updated study primarily followed the methodology used in the 1983-84 study, including the thickness incremental method for highway construction, traditional incremental method for bridge construction and rehabilitation and aggregated highway performance analysis for highway rehabilitation and maintenance cost allocation.

The study was initiated in August, 1988. The input from a group of representatives from the trucking industry was sought and received. The input primarily consisted of traffic data representing the distribution of truck operating weights and the extent of vehicle- miles of travel on local roads. This information was combined with the data collected in the updating study.

The vehicle classification used in the present study was somewhat different from the earlier study. Some of the earlier vehicle classes were combined and new classes were included to reflect the changing vehicle types. The overall classification of all vehicles in four categories of passenger car, bus, single unit truck and combination truck, remained the same. It should be noted that each vehicle subclass was further subdivided in a number

of weight groups in computing cost responsibilities.

An extensive traffic data collection program was undertaken in cooperation with the Indiana Department of Highways and Indiana State Police. Traffic data collected included volume and composition, truck operating weight and registered weight, and the state of registration.

The updated study findings indicated that a significant imbalance still exists between cost responsibility and revenue contribution by different vehicle classes. In FY 1988 passenger cars, including pickups and vans, overpaid their cost responsibility by about 29 percent, while heavy combination trucks underpaid their cost responsibility by about 35 percent. Buses slightly underpaid their cost responsibility; however, this vehicle class included proportionately a high percentage of exempt vehicles. Single unit trucks, as a class, on the other hand, slightly overpaid their cost responsibility.

Although the passenger cars as a group overpaid, the extent of overpayment was significantly high for large passenger cars than small cars; the overpayment by large cars was about 39%, while the overpayment by small cars was only 7%. In the single unit truck category, 2-axle trucks overpaid by about 22%, while 3-axle trucks slightly overpaid and 4-axle trucks slightly underpaid. All five vehicle subclasses in the combination truck category underpaid their cost responsibility.

The subsidization of heavy commercial vehicles by passenger cars and light weight single unit trucks, revealed in the 1983 Cost Allocation Study, is thus still continued, even though the revenue/cost ratio for combination trucks, as a whole, was somewhat better in 1988 than what it was in 1983.

CHAPTER ONE

INTRODUCTION

This study, entitled 1988 Update of the Indiana Highway Cost-Allocation Study, was initiated in August, 1988. The updated study primarily followed the methodology used in the 1983-84 study [Sinha et al. 1985]. This report presents the results, findings and conclusions of the study based on updated traffic composition, travel and levels of expenditure and revenue.

Purpose of the Study

The main purpose of the updating was to derive the cost responsibilities and revenue contributions of various vehicle classes with input data for 1988. The revenue contribution of each vehicle class was compared with its cost responsibility. This comparison would enable one to determine the contribution of each user class in relation to its cost responsibility. It should be noted that all cost responsibility and revenue contribution factors were computed as a percentage value. For example, the total cost of highway construction was allocated among vehicle classes in terms of relative percentage values. The same was done for estimating contributed revenues by various vehicle classes. This procedure allowed the consideration of all user revenues, even though some of them were not used in highway activities.

Highway Classification

The adopted 1988 highway classification was the same as in the 1983 study, as indicated below:

1. Interstate Urban

2. Interstate Rural

3. State Route Primary

4. State Route Secondary

5. County Road

6. City Street

Vehicle Classification

The vehicle classification used in the present study was somewhat different from the earlier study. Some of the earlier vehicle classes were combined and new classes were included to consider the changes in the FHWA truck study classifications. The overall classification of all vehicles in four categories of passenger car, bus, single unit truck and combination truck, remained the same. In the present study vehicles were grouped into eleven classes as defined in Table 1. It should be noted that eight truck classes were further subdivided in a number of operating weight subgroups based on data collected from truck-weighing stations and these weight groups were used in computing cost responsibilities. The weight subgroups used for each vehicle class are presented in Table 2. The axle configuration characteristics of eleven vehicle classes are shown in Table 3. The correspondence between the 1988 study vehicle classes and AASHTO vehicle types for bridge design [AASHTO 1977], used in the allocation of bridge costs, is presented in Table 4.

Table 1. Adopted Vehicle Classification: 1988 Study.

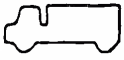
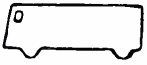
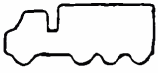
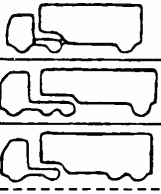
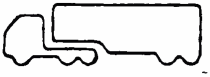
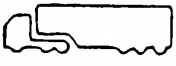
Class	Vehicle Type	Description
1		Small Passenger Car
2		Large Passenger Car including Pickup and Van
3		2 Axle Single Unit Truck
4		Bus
5		3 Axle Single Unit Truck
6		4 Axle Single Unit Truck
7		3 or 4 Axle Combination Truck
8		5 Axle 1 Trailer Combination Truck
9		5 Axle Multiple Trailer Combination Truck
10		6 Axle 1 Trailer Combination Truck
11		6 or More Axle Multiple Trailer Truck or Any 7 Axle Combination

Table 2. Vehicle Class Weight Group Classification.

Vehicle Class	Weight Group	Weight in Pounds
1	1	All
2	1	All
3	1	<7500
3	2	7500-10,000
3	3	10,000-12,500
3	4	12,500-15,000
3	5	15,000-17,500
3	6	17,500-20,000
3	7	20,000-22,500
3	8	22,500-25,000
3	9	>25,000
4	1	All
5	1	<17,500
5	2	17,500-20,000
5	3	20,000-22,500
5	4	22,500-25,000
5	5	25,000-27,500
5	6	27,500-30,000
5	7	30,000-32,500
5	8	32,500-35,000
5	9	>35,000
6	1	All
6	2	<22,500
6	3	>22,500
7	1	<22,500
7	2	22,500-25,000
7	3	25,000-27,500
7	4	27,500-30,000
7	5	30,000-32,500
7	6	32,500-35,000
7	7	35,000-37,500
7	8	37,500-40,000
7	9	40,000-42,500
7	10	42,500-45,000
7	11	45,000-47,500
7	12	47,500-50,000
7	13	50,000 & Above
8	1	<22,500
8	2	22,500-25,000
8	3	25,000-27,500
8	4	27,500-30,000
8	5	30,000-32,500
8	6	32,500-35,000
8	7	35,000-37,500
8	8	37,500-40,000
8	9	40,000-42,500
8	10	42,500-45,000
8	11	45,000-47,500
8	12	47,500-50,000
8	13	50,000-52,500
8	14	52,500-55,000
8	15	55,000-57,500
8	16	57,500-60,000
8	17	60,000-62,500
8	18	62,500-65,000
8	19	65,000-67,500
8	20	67,500-70,000
8	21	70,000-72,500
8	22	72,500-75,000
8	23	75,000-77,500
8	24	77,500-80,000
8	25	80,000-82,500
8	26	82,500 & Above
9	1	<42,500
9	2	42,500-45,000
9	3	45,000-47,500
9	4	47,500-50,000
9	5	50,000-52,500
9	6	52,500-55,000
9	7	55,000-57,500
9	8	57,000-60,000
9	9	60,000-62,500
9	10	62,500-65,000
9	11	65,000-67,500
9	12	67,500-70,000
9	13	70,000 & Above
10	1	<40,000
10	2	40,000-60,000
10	3	>60,000
11	1	<40,000
11	2	40,000-60,000
11	3	>60,000

Table 3. Axle Configuration Characteristics of Vehicle Classes

Vehicle Class	Total Number of Axles	Number of Axle Type		
		Single	Tandem	Triple
1	2	2		
2	2	2		
3	2	2		
4	2	2		
5	3	1	1	
6	4	1		1
7	3 or 4	3 or 2	0 or 1	
8	5	1	2	
9	5	5		
10	6	1	1	1
11	6 or more	4 or more	1	

Table 4. AASHTO Bridge Design Vehicle and 1988 Cost Allocation Study Vehicle Correspondence Matrix

AASHTO HS	AASHTO H	1988 Vehicle Class (i) 1	2	3	4	5	6	7	8	9	10	11
1	1.5											
2	2.9	*										
3	4.4		*									
4	5.9			V31								
5	7.4			V32								
6	8.8			V33		V51						
7	10.3			V34		V52		V71+V72	V81+V82			
8	11.8			V35		V53		V73+V74	V83+V84			
9	13.2			V36		V54		V75+V76	V85+V86			
10	14.7			V37		V55		V77+V78	V87+V88	V91+V92		
11	16.2			V38	*	V56		V79+V710	V89+V810	V93+V94	V101	
12	17.7			V39		V57		V711	V811+V812	V95+V96		
13	19.1					V58		V712	V813+V814	V97+V98		
14	20.6					V59		V713	V815+V816	V99+V910		
15	22.1								V817+V818	V911+V912		
16	23.5								V819+V820	V913		
17	25.1								V821+V822			
18	26.5								V823+V824		V102	V111
19	27.9								V825			
20	29.4								V826			
21	30.9						V61					V112
22	32.3						V62					
23	33.8										V103	V113
24	35.3											
25	36.8											

* = No Sub-Group
Vij, i = Vehicle Class & j= Weight Group

Allocated Costs

The actual highway expenditure for fiscal year 1988 was considered in the present study. Only the expenditure supported by user revenue contribution was included. The fact that actual expenditures and revenues are used in this type of study explains why such a study has to be carried out from time to time to check that each user group is paying its fair share of responsibility. A breakdown of the total expenditure for the state highway and local road system supported by user revenue in terms of major cost categories for the fiscal year 1988 is presented in Table 5.

Attributed Revenues

Revenues considered in the present study were those contributed by Indiana highway users. The FY 1988 revenues, by source, for the state of Indiana are presented in Table 6. It should be noted that not all of the amount reported in Table 6 was available for highway activities. A part was used for the Bureau of Motor Vehicles and Indiana State Police.

The major portion of revenue is from state gasoline tax, vehicle registration fees and diesel surtax. The diesel surtax is an add-on tax charged on all diesel fuel consumed in Indiana and collected from trucking companies. State motor carrier fuel use tax (MCFUT) is collected from all commercial vehicles for the fuel not purchased in Indiana but consumed on Indiana roads. The data on vehicle registration, license and title fees were obtained from the Bureau of Motor Vehicles and the IDOH. International Registration Plan (IRP) is a reciprocity agreement on motor carrier registration fees. This fee is collected from interstate carriers from those states with which Indiana has

Table 5. Expenditure* Distribution for Fiscal Year 1988.

A. State Highway System (Interstate, Primary and Secondary)

1.	Highway Construction	$201,229,460
2.	Highway Rehabilitation	$131,440,745
3.	Highway and Bridge Maintenance	$142,495,591
4.	Bridge Construction and Replacement	$ 13,070,833
5.	Bridge Rehabilitation	$ 64,586,263
	Total (State Highway System)	$552,822,892

B. Local Road System (County Road and City Street)

1.	Road Construction	$ 29,968,730
2.	Road Rehabilitation	$ 60,830,560
3.	Road and Bridge Maintenance	$162,096,710
4.	Bridge Construction and Replacement	$ 526,500
5.	Bridge Rehabilitation	$ 26,003,500
	Total (Local Road System)	$279,426,000
	Total (State and Local)	$832,248,892

* Includes only the expenditure supported by user revenues.

Table 6. Revenue Distribution for Fiscal Year 1988 (*)

Revenue Source	Revenue (in million dollars)
1. State Gasoline Tax	380.95
2. State Special Fuel Tax	82.80
3. Diesel Surtax	43.22
4. Motor Carrier Fuel Use Tax	6.89
5. Vehicle Registration, License and Title Fees	105.04
6. International Registration Plan	22.21
7. Oversize/Overweight Permits	3.53
8. Federal:	
a. Gasoline Tax	118.10
b. Diesel Tax	78.70
c. Heavy Vehicle User Fee	17.22
d. New Truck and Trailer Sale	23.26
e. Tire Tax	8.75
9. Local Option Tax	12.00
TOTAL	$902.67

(*) Not all amounts were available for highway activities

a reciprocity agreement. The information was obtained from the Bureau of Motor Vehicles. Oversize/overweight permit fees are collected by the IDOH.

Federal revenue sources include fuel taxes and other taxes and fees. In 1988, other taxes and fees included tax on tires, new truck and trailer sale, and heavy vehicle user fee. It can be noted in Table 6 that the major portion of user revenues included state and federal fuel taxes and state registration fees.

CHAPTER TWO

STUDY METHODOLOGY

The 1988 updated study primarily followed the methodology used in the 1983-84 study including the thickness incremental method for highway construction, traditional incremental method for bridge construction and rehabilitation, and aggregated highway performance analysis for highway rehabilitation and maintenance cost allocation. The details of the above methods can be found in Sinha et al. [1985], Sinha et al. [1984] and Fwa [1985]. The following sections will provide a framework of the overall updating study approach. The discussion primarily involves the applicability of the 1983-84 study methodology with respect to the 1986 AASHTO Guide.

Framework of Overall Study Approach

As with the 1983 Cost Allocation Study [Sinha et al. 1985], the 1988 study was also based on an extensive data collection effort to obtain information on highway traffic, highway expenditures and user revenues. The collected data were then processed to provide input information to the cost-allocation and revenue attribution analyses. A more detailed discussion on data collection and analysis is presented in Appendix A.

Each expenditure item was examined to determine the proportions of attributable and non-attributable costs. Next, appropriate cost-allocators were used to distribute those costs among vehicle classes. [See Table 7 of Sinha et al. 1985]. Revenue attribution was accomplished by examining the sources of revenues paid by Indiana highway users and then apportioning the revenue

amounts by vehicle class.

The environmental and climatic conditions in the north and south regions of Indiana are different and consequently pavement and structure damages caused by load and interaction of load and environment are also different. Thus, it was necessary to consider north and south regions in allocating pavement rehabilitation and maintenance costs. The load-related cost responsibility factors were computed using Equations 5.3 and 5.4 given in Fwa [1985].

The overall cost-responsibility of each vehicle class was computed by summing the cost responsibility associated with each vehicle class for each expenditure item within a cost category. Figures 1 through 5 present flow diagrams of the step-by-step cost-responsibility computations. Expenditure item cost responsibility factors were first applied to their corresponding expenditure amounts to obtain aggregated expenditure category cost-responsibility factors, as shown in Figures 2 through 5. These factors were then used to compute the overall cost-responsibility by vehicle class, as shown in Figure 1.

Remarks on ESAL and Thickness Incremental Method

The computation of equivalent single axle loads (ESAL) in the Thickness Incremental Method used in the 1983-84 Cost Allocation Study [Sinha et al. 1985] was based on 1981 AASHTO Guide. The applicability of the 1983-84 study with respect to the 1986 AASHTO Guide is discussed in this section.

a. ESAL: Equivalent Single Axle Load (ESAL) computation is the same in both the old and new AASHTO procedures. Identical set of formulae are

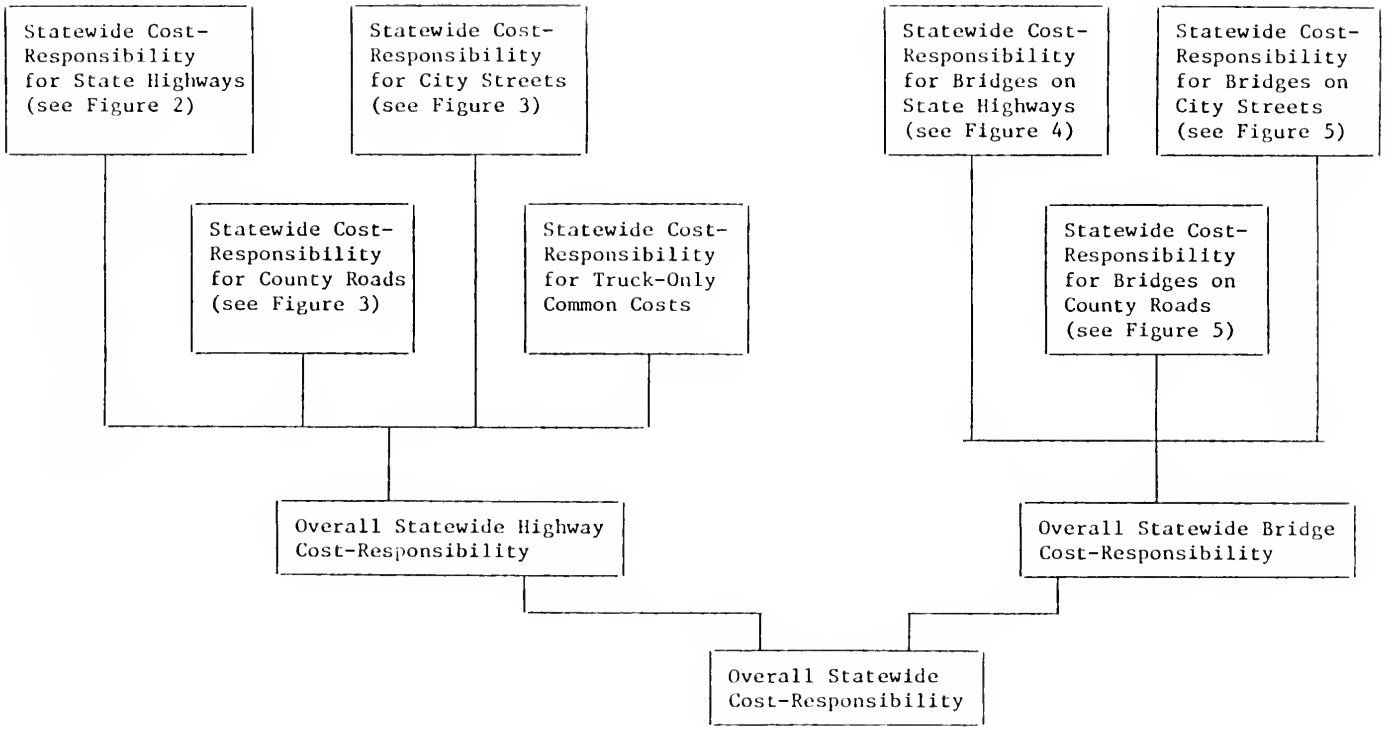


Figure 1. Computation of Overall Statewide Vehicle Class Cost-Responsibilities.

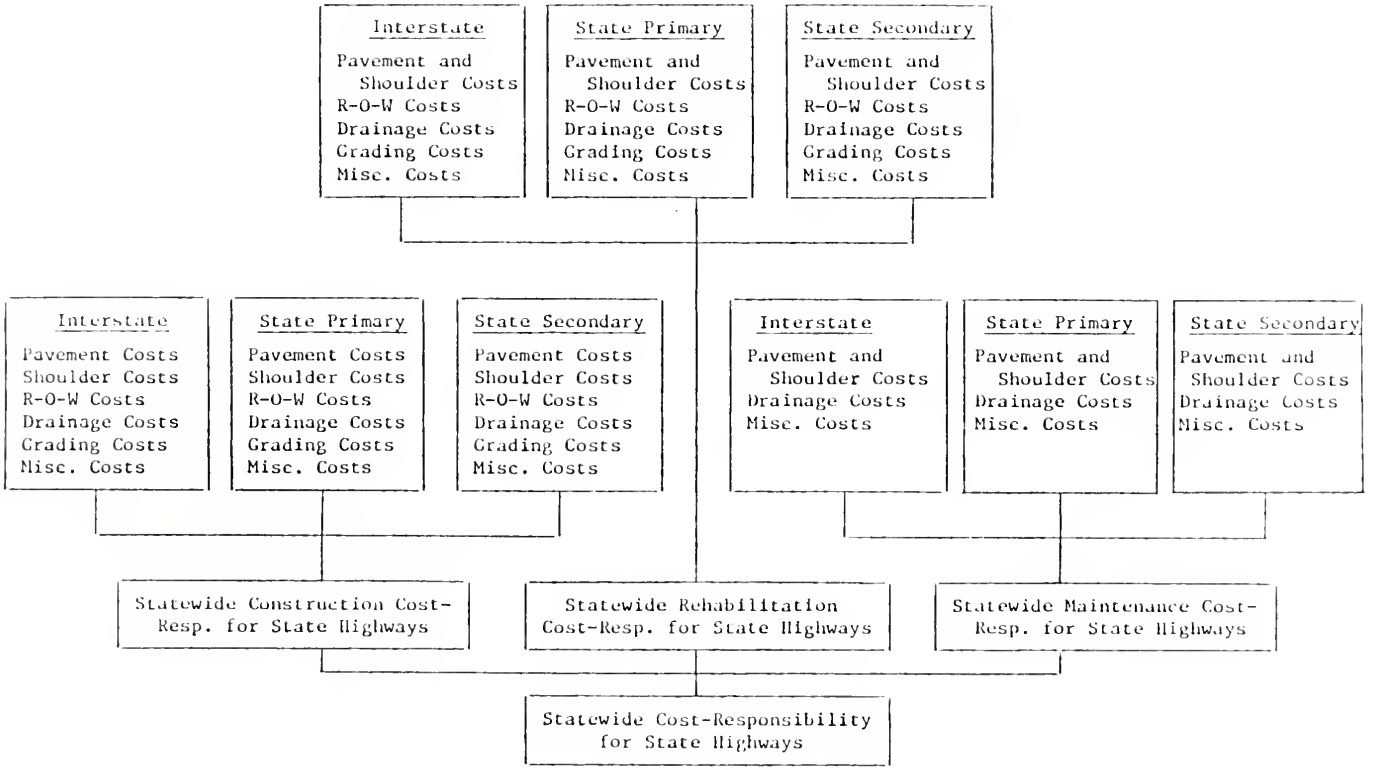


Figure 2. Computation of Statewide Vehicle Class Cost-Responsibilities for State Highways

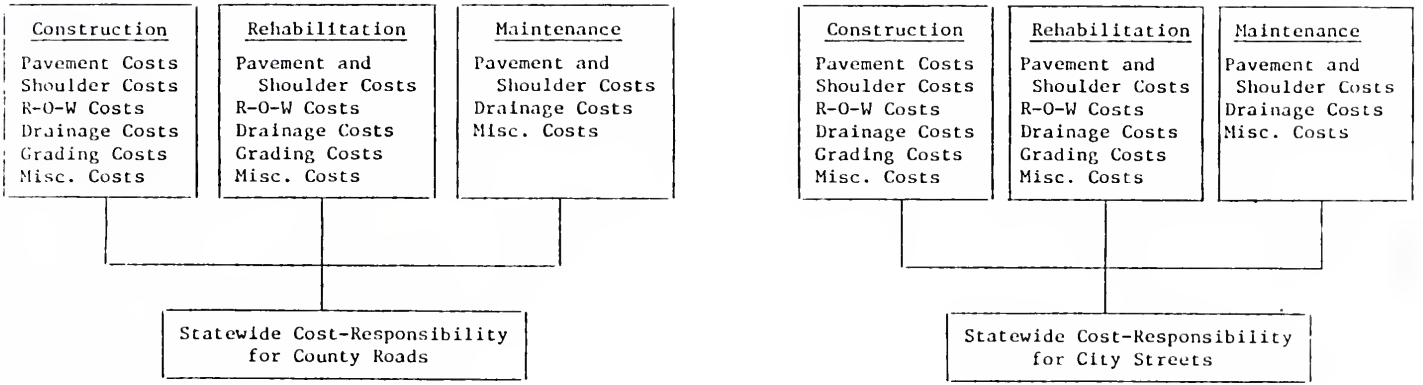


Figure 3. Computation of Statewide Cost-Responsibilities for (a) County Roads, and (b) City Streets

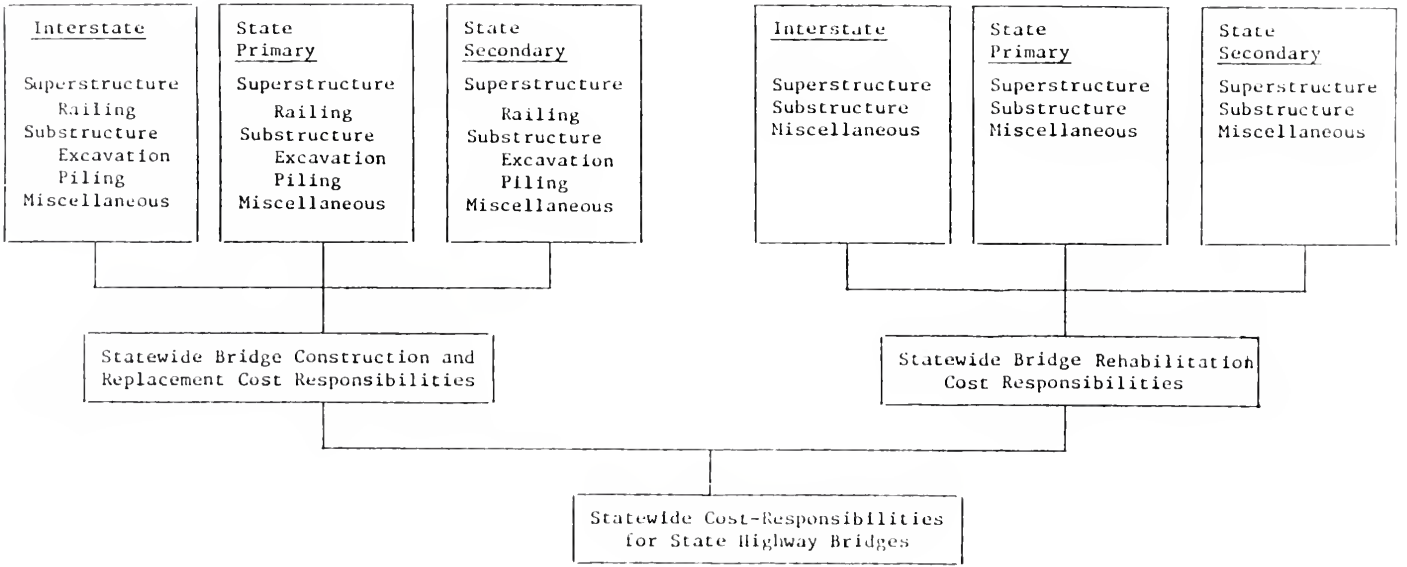


Figure 4. Derivation of Statewide Cost-Responsibilities for State Highway Bridges

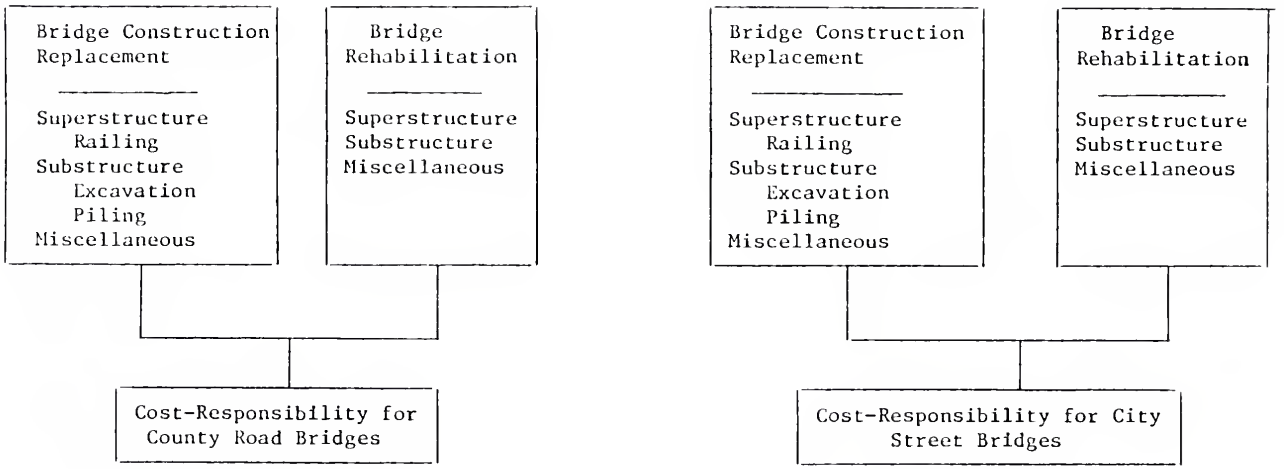


Figure 5. Derivation of Statewide Cost-Responsibilities for Bridges on County Roads and City Streets.

used in ESAL calculations for single, tandem and tridem axles respectively (see 1981 AASHTO Guide Appendices C and D and 1986 AASHTO Guide Appendix D).

b. Thickness Incremental Method: The validity of the Thickness Incremental Method was not affected by the introduction of new design formulae in the 1986 AASHTO guide, as indicated below.

Case 1 Flexible Pavement Thickness (T)

1981 AASHTO Procedure: T = f(soil support value, regional factor, Δ PSI, pavement structural number, ΣESAL)

1986 AASHTO Procedure: T = f(soil resilient modulus, reliability factor, drainage coefficient, Δ PSI, ΣESAL)

For a given thickness cost to be allocated, design factors are fixed for the given location and pavement constructed. Now, regardless of old or new procedures, we have

$$T = f(\text{constants}, \Sigma ESAL)$$

i.e. thickness variation in both formulae is essentially a function of ΣESAL. Since ESAL computation remains the same for both 1981 and 1986 procedures, the following equations could be written:

1981 AASHTO procedure: $T_1 = f_1(\Sigma ESAL)$

1986 AASHTO procedure: $T_2 = f_2(\Sigma ESAL)$

For each increment of thickness, $\Delta T = \Delta T_1 = \Delta T_2$, the corresponding changes in ΣESAL are different. In other words, $\Delta(\Sigma ESAL)_1 \neq \Delta(\Sigma ESAL)_2$. But the cost allocation analysis is based on variation in relative contributions of different vehicle group ESAL values and not on total amount of changes in respective ESAL values. In other words, $\frac{(\Sigma ESAL)_2}{(\Sigma ESAL)_1} = k$ (constant). Now, knowing traffic composition of different vehicle classes, we can obtain the ESAL equations as:

1981 AASHTO Procedure: $(\Sigma ESAL)_1 = C_1 (n_1+n_2+....+n_i)$

1986 AASHTO Procedure: $(\Sigma ESAL)_2 = C_2 (n_1+n_2+....+n_i)$

Here, $n_1, n_2,...,n_i$ are ESAL factors at thickness $(T_i + \Delta T_i)$ for different vehicle groups, and their relative magnitudes would vary with thickness. C_1 and C_2 are constants for 1981 and 1986 procedures respectively. Using the above relations, the following equations could be written for cost-responsibility (CR) for vehicle class i as follows:

1981 AASHTO Procedure:

$$(CR)_i = \frac{C_1 n_i}{C(n_1 + n_2 +...+ n_i + ...+ n_n)} = \frac{n_i}{n_i + n_2 +...+ n_i +...+ n_n}$$

1986 AASHTO Procedure:

$$(CR)_i = \frac{C_2 n_i}{C_2(n_1 + n_2 +...+ n_i + ...+ n_n)} = \frac{n_i}{n_i + n_2 +...+ n_i +...+ n_n}$$

The above two equations show that identical cost responsibility factors are obtained using both 1981 and 1986 AASHTO procedures. Thus, the thickness incremental concept remains valid under the 1986 AASHTO procedure. It should be mentioned that tridem-axle configuration was considered for Vehicle Classes 6 and 10 in the present update study.

CHAPTER THREE

RESULTS OF COST-ALLOCATION AND REVENUE CONTRIBUTION ANALYSIS

Cost Responsibility Factors

The results presented in this chapter follow the framework of the study shown in Figures 1 through 5 of Chapter 2. The cost responsibility factors developed in the analysis were on the basis of FY 1988 expenditures. The cost responsibilities for highway and bridge expenditures were computed separately and were then combined to compute the statewide overall cost-responsibility factors (see Figure 1 of Chapter 2). The overall statewide vehicle class cost-responsibilities for Fiscal Year 1988 are presented in Table 7. The overall statewide vehicle class cost-responsibilities for highways and bridges for Fiscal Year 1988 are presented in Table 8 and 9, respectively. Tables 7 through 9 also indicate the cost responsibilities by weight group in each vehicle class. The subgroups of each vehicle class are defined in Table 2 of Chapter 1. It can be noted that overall statewide cost responsibility factors are higher for the highway part, because of higher expenditure on pavements and shoulders as compared to bridges.

The overall cost responsibilities in FY 1988 were 44.60, 2.20, 14.30 and 38.90 percent for passenger car (Vehicle Classes 1 and 2), Bus (Vehicle Class 4), Single Unit Truck (Vehicle Classes 3, 5 and 6) and Combination Truck (Vehicle Class 7 through 11), respectively. Cost responsibilities for small and large passenger cars were 13.70 and 30.90 percent, respectively. The cost responsibilities for Vehicle Classes 3, 5 and 6 of Single Unit Truck were 4.90, 3.40 and 6.00 percent, respectively. The cost responsibilities for

Table 7. Overall Statewide Cost-Responsibility for Year 1988

Vehicle Class	Sub-Group	% Responsibility Veh-Class	% Responsibility Subgroup	Vehicle Class	Sub-Group	% Responsibility Veh-Class	% Responsibility Subgroup
1	1	13.70	13.70	8	1	29.00	0.08
				8	2		0.10
2	1	30.90	30.90	8	3		0.44
				8	4		1.03
3	1	4.90	0.16	8	5		0.69
3	2		0.21	8	6		0.55
3	3		0.53	8	7		0.42
3	4		0.71	8	8		0.51
3	5		0.41	8	9		0.52
3	6		1.10	8	10		0.60
3	7		0.78	8	11		0.61
3	8		0.35	8	12		0.46
3	9		0.65	8	13		0.60
				8	14		0.98
4	1	2.20	2.20	8	15		1.00
				8	16		1.32
5	1	3.40	0.46	8	17		1.34
5	2		0.33	8	18		2.37
5	3		0.30	8	19		2.57
5	4		0.37	8	20		3.07
5	5		0.14	8	21		3.26
5	6		0.20	8	22		2.80
5	7		0.18	8	23		2.25
5	8		0.36	8	24		0.91
5	9		1.06	8	25		0.21
				8	26		0.31
6	1	6.00	0.29				
6	2		5.71	9	1	0.70	0.05
				9	2		0.08
7	1	6.10	0.13	9	3		0.06
7	2		0.30	9	4		0.05
7	3		0.53	9	5		0.06
7	4		0.36	9	6		0.04
7	5		0.31	9	7		0.04
7	6		0.87	9	8		0.07
7	7		0.25	9	9		0.07
7	8		0.38	9	10		0.05
7	9		0.31	9	11		0.05
7	10		0.46	9	12		0.01
7	11		0.46	9	13		0.07
7	12		0.52				
7	13		1.22	10	1	2.30	0.31
				10	2		0.56
				10	3		1.43
				11	1	0.80	0.08
				11	2		0.18
				11	3		0.54

Table 8. Overall Statewide Highway Cost-Responsibility for Year 1988

Vehicle Class	Sub-Group	% Responsibility Veh-Class	% Responsibility Subgroup
1	1	14.10	14.10
2	1	31.40	31.40
3	1	5.00	0.14
3	2		0.19
3	3		0.46
3	4		0.67
3	5		0.42
3	6		1.12
3	7		0.89
3	8		0.37
3	9		0.74
4	1	2.20	2.20
5	1	3.40	0.46
5	2		0.32
5	3		0.30
5	4		0.37
5	5		0.14
5	6		0.20
5	7		0.17
5	8		0.37
5	9		1.07
6	1	5.10	0.13
6	2		4.97
7	1	6.50	0.12
7	2		0.31
7	3		0.53
7	4		0.37
7	5		0.32
7	6		0.93
7	7		0.26
7	8		0.42
7	9		0.33
7	10		0.48
7	11		0.54
7	12		0.56
7	13		1.33
8	1	29.50	0.09
8	2		0.10
8	3		0.43
8	4		1.01
8	5		0.65
8	6		0.54
8	7		0.39
8	8		0.45
8	9		0.50
8	10		0.60
8	11		0.58
8	12		0.45
8	13		0.59
8	14		1.02
8	15		1.04
8	16		1.35
8	17		1.37
8	18		2.48
8	19		2.62
8	20		3.21
8	21		3.41
8	22		2.91
8	23		2.26
8	24		0.93
8	25		0.22
8	26		0.30
9	1	0.70	0.05
9	2		0.08
9	3		0.06
9	4		0.05
9	5		0.06
9	6		0.04
9	7		0.04
9	8		0.07
9	9		0.07
9	10		0.05
9	11		0.05
9	12		0.01
9	13		0.07
10	1	1.50	0.28
10	2		0.42
10	3		0.80
11	1	0.60	0.05
11	2		0.11
11	3		0.44

Table 9. Overall Statewide Bridge Cost-Responsibility for Year 1988

Vehicle Class	Sub-Group	% Responsibility Veh-Class	% Responsibility Subgroup
1	1	11.52	11.52
2	1	27.14	27.14
3	1	4.26	0.30
3	2		0.27
3	3		0.75
3	4		0.81
3	5		0.47
3	6		0.72
3	7		0.40
3	8		0.24
3	9		0.30
4	1	2.30	2.30
5	1	3.28	0.48
5	2		0.40
5	3		0.28
5	4		0.37
5	5		0.16
5	6		0.19
5	7		0.21
5	8		0.26
5	9		0.93
6	1	12.41	1.43
6	2		10.98
7	1	3.66	0.20
7	2		0.25
7	3		0.52
7	4		0.29
7	5		0.27
7	6		0.50
7	7		0.19
7	8		0.19
7	9		0.18
7	10		0.17
7	11		0.21
7	12		0.25
7	13		0.44
8	1	24.99	0.03
8	2		0.13
8	3		0.50
8	4		1.22
8	5		0.86
8	6		0.63
8	7		0.53
8	8		0.57
8	9		0.62
8	10		0.59
8	11		0.70
8	12		0.50
8	13		0.63
8	14		0.86
8	15		0.97
8	16		1.11
8	17		1.17
8	18		1.61
8	19		2.30
8	20		1.99
8	21		2.24
8	22		2.10
8	23		1.85
8	24		0.75
8	25		0.17
8	26		0.36
9	1	0.60	0.06
9	2		0.09
9	3		0.03
9	4		0.04
9	5		0.03
9	6		0.02
9	7		0.05
9	8		0.06
9	9		0.07
9	10		0.05
9	11		0.03
9	12		0.03
9	13		0.04
10	1	7.59	0.32
10	2		1.49
10	3		5.78
11	1	2.25	0.37
11	2		0.68
11	3		1.20

Vehicle Classes 7, 8, 9, 10 and 11 of Combination Truck were 6.10, 29.00, 0.70, 2.30 and 0.80 percent, respectively. While the high percentage of cost responsibility for large passenger cars (Vehicle Class 2) was primarily due to their high percentage of VMT, the high cost responsibility for 5-axle tractor-trailer combination trucks was primarily the result of high VMT within the truck category as well as of axle weight distribution and associated damage effects.

Revenue Contribution by Vehicle Class

The revenue contribution figures were computed by examining each revenue source and accounting for the share of each of the vehicle classes. Distribution of revenues into eleven vehicle classes was primarily based on proportion of vehicle-miles of travel and proportion of numbers of vehicle units, as required by particular tax types. Other information included such items as fuel efficiency values. For example, fuel taxes were distributed by converting vehicle-miles of travel into gallons of fuel by using vehicle class specific fuel efficiency values. The total revenue amounts were then computed by applying appropriate tax rates per gallon. On the other hand, revenues, such as registration fees, were distributed in proportion of the product of number of units in a specific vehicle subclass and the associated registration fee rate. The revenue contribution figures for the eleven vehicle classes for FY 1988 are presented in Table 10. It can be noted that the revenue contribution had, in general, the same trend as the cost responsibility. For example, the three vehicle classes with the highest revenue contribution figures were Vehicle Class 2 (large cars), Vehicle Class 8 (5-axle combination trucks) and Vehicle Class 1 (small cars). The same trend was also observed in cost

Table 10. 1988 Indiana Highway Cost Responsibility and Revenue Contribution Summary.

Summary For Fiscal Year 1988

Vehicle Type	Vehicle Class	Percent VMT	Percent Cost Responsibility	Percent Revenue Contribution	Revenue/ Cost
Passenger	1	32.50	13.70	14.68	1.071
Car	2	55.92	30.90	42.82	1.385
		88.42	44.60	57.50	1.289
Bus	4	0.57	2.20	2.00	0.909
Single Unit	3	1.91	4.90	5.99	1.222
Truck	5	1.00	3.40	3.55	1.044
	6	0.34	6.00	5.46	0.910
		3.26	14.30	15.00	1.050
Combination	7	1.30	6.10	4.24	0.695
Truck	8	5.65	29.00	18.65	0.643
	9	0.22	0.70	0.61	0.871
	10	0.49	2.30	1.50	0.652
	11	0.09	0.80	0.50	0.625
		7.75	38.90	25.50	0.655

responsibility figures.

Comparison of FY 1988 Cost-Responsibility with Revenue Contribution

The information on cost-responsibility, revenue contribution and percent VMT of vehicle classes is presented in Table 10, along with revenue/cost ratios. Revenue-cost ratios indicate the equity in revenue contribution. The 1988 update study revealed that passenger cars including pickups and vans and single-unit trucks were overpaying by about 29 percent, while heavy combination trucks were underpaying their cost responsibilities by about 35 percent. Further, while passenger cars as a group were overpaying, there was a significant difference in the extent of overpayment by two vehicle classes; large cars overpaid by about 39 percent and small cars by only 7 percent.

Single-unit trucks as a group also overpaid their cost responsibility in 1988, although not to the same extent as passenger cars. There was also a considerable inequity within the group. While the revenue contribution by 3-axle (Vehicle Class 5) trucks was almost equal to the cost responsibility (revenue/cost = 1.044), 2-axle (Vehicle Class 3) and 4-axle (Vehicle Class 6) single-unit trucks overpaid and underpaid their cost-responsibilities by about 22 percent and 9 percent, respectively. Buses underpaid their cost responsibility by about 9 percent. However, this vehicle class included proportionately a high percentage of exempt vehicles.

Combination trucks significantly underpaid their cost-responsibilities. The underpayment was consistent among all vehicle classes with this category. However, the extent of the underpayment varied within the classes. For example, Vehicle Class 9 (5-axle multiple trailer combination truck) had a higher

revenue/cost ratio than Vehicle Class 8 (5-axle single trailer truck). In general, multiple-trailer combination trucks cause less damage than single trailer combination trucks. However, the same trend was not observed in the case of Vehicle Class 11. The small volume of travel recorded in the sample for this vehicle class along with the difficulty of determining the number of units might have contributed to the apparent discrepancy.

Considering the four major vehicle groups, all passenger cars together made an overpayment of $107,360,000 in excess of their cost responsibility in FY 1988. Single-unit trucks as a group contributed $5,826,000 in excess of their cost responsibility. However, buses underpaid $1,665,000 and combination trucks as a group paid $111,521,000 less than their cost responsibility. The net effect was that passenger cars and single-unit trucks subsidized buses and combination trucks.

Comparison of 1988 Update Study with 1983-84 Study

A comparison of results from the 1988 update study and 1983-84 study is presented in Table 11. The correspondence of vehicle classes between the two study years is indicated. For example, Vehicle Class 14 in FY 1983-84 was divided between Vehicle Classes 10 and 11 in FY 1988 study. On the other hand, Vehicle Class 7 in FY 1988 study included Vehicle Classes 7, 10 and 11 in FY 1983-84. In case of passenger cars in FY 1988, Vehicle Class 1 represented small passenger cars and Vehicle Class 2 represented large autos, autos with trailer as well as pickups and vans.

Comparing the revenue/cost ratios, the same trend of subsidization of combination trucks and buses by passenger cars and single unit trucks was

Table 11. Comparison between 1983-84* and 1988 Indiana Cost-Allocation Study by Vehicle Type and Class.

Vehicle Type	1988 Veh. Class	1983-84 Veh. Class	Percent Cost-Resp. 1988	Percent Cost-Resp. 1983-84	Percent Revenue 1988	Percent Revenue 1983-84	Revenue/Cost 1988	Revenue/Cost 1983-84
Passenger	1	1	13.70	10.869	14.68	8.080	1.071	0.743
Car	2	2+5+8	30.90	41.978	42.82	57.201	1.385	1.363
			44.60	52.847	57.50	65.281	1.289	1.235
Bus	4	4	2.20	0.448	2.00	0.372	0.909	0.830
Single-	3	3	4.90	6.766	5.99	8.020	1.222	1.185
Unit	5	6	3.40	2.605	3.55	2.210	1.044	0.848
Truck	6	9	6.00	1.087	5.46	1.620	0.910	1.490
			14.30	10.458	15.00	11.850	1.050	1.133
Combi-	7	7+10+11	6.10	3.606	4.24	1.820	0.695	0.505
nation	8	12	29.00	30.253	18.65	18.900	0.643	0.625
Truck	9	13	0.70	1.285	0.61	1.260	0.871	0.981
	10	14	2.30		1.50		0.652	
	11	14	0.80	1.110	0.50	0.520	0.625	0.468
			38.90	36.254	25.50	22.500	0.655	0.621

*Source: Sinha et al. [1985]

observed in 1988, although the revenue-cost ratio for combination trucks improved since 1983-84. It should be noted that the revenue contribution analysis in 1988 included the changes in highway taxation structure enacted since the 1983-84 study was completed, except the $50 cab fee for interstate commercial vehicles.

Table 11 findings show that while the revenue/cost ratio for single unit trucks decreased in year 1988 compared to year 1983-84, there was a significant difference in revenue/cost ratios within the group. In particular, revenue/cost ratios for Vehicle Classes 3 and 5 in 1988 study increased and that for Vehicle Class 6 decreased. Moreover, Vehicle Class 5 overpaid about 4.4 percent in 1988 but it was underpaying 15.2% in year 1983-84. The Vehicle Class 6 underpaid by 9% in 1988, while it overpaid by as much as 49% in 1983-84. One of the primary reasons for this significant change is its share of percent-VMT. However, an increase in percent VMT does not necessarily imply a corresponding decrease in revenue/cost ratio. There are other factors that affect the revenue-cost ratio results. These include ESAL-computation procedure, distribution of cost among cost-elements, axle load distribution characteristics, and the amount of revenue contribute by the vehicle class.

Combination-trucks indicated a better revenue-cost ratios in 1988 than in 1983-84. There were, however, some changes in revenue-cost figures for vehicle classes within the group. Combination-trucks as a group underpaid by 34.5% in 1988, while the underpayment was about 38% in 1983-84.

Overall cost-responsibilities for bus, single unit truck and combination truck increased by about 1.75, 3.84 and 2.65 percent, respectively in year

1988. But, the overall cost-responsibility for passenger car decreased by about 8.25% in 1988. On the other hand, revenue-contribution by bus, single unit truck and combination truck increased by about 1.63, 3.15 and 3.00 percent, respectively in 1988. Revenue-contribution for passenger car decreased by 7.781 percent in 1988. These results reflect the changes that have taken place in highway programs, revenue amounts and other contributing factors since 1983-84.

CHAPTER FOUR

CONCLUSIONS

This report presented the findings of the 1988 update of the Indiana highway cost-allocation study. The updated study followed the methodology used in the 1983-84 study, including the thickness incremental method for highway construction, traditional incremental method for bridge construction and rehabilitation, and aggregated highway performance analysis for highway rehabilitation and maintenance cost allocation.

The study indicated that a significant imbalance still existed between cost responsibility and revenue contribution by different vehicle classes. In FY 1988 passenger cars including pickups and vans and single-unit trucks as a group contributed more revenue than their cost responsibility, while buses and heavy combination trucks contributed less revenue than their cost responsibility. In particular, passenger cars including pickups and vans overpaid their cost responsibility by about 29 percent, while heavy combination trucks underpaid their cost responsibility by about 35 percent. Buses slightly underpaid their cost responsibility; however, this vehicle class includes proportionately a high percentage of exempt vehicles. Single unit trucks, as a group, on the other hand, slightly overpaid their cost responsibility.

Although the passenger cars as a group overpaid, the extent of overpayment is significantly high for large passenger cars than small cars; the overpayment by large cars was about 39%, while the overpayment by small cars was only 7 percent. In the single unit truck category, 2-axle trucks overpaid by

about 22%, while 3-axle trucks slightly overpaid and 4-axle trucks slightly underpaid. All five vehicle subclasses in the combination truck category underpaid their cost responsibility.

The subsidization of combination trucks and buses by passenger cars and single unit trucks, revealed in the 1983 Cost Allocation Study, was thus still continued, even though the revenue/cost ratio for combination trucks, as a whole, was somewhat better in 1988 than it was in 1983.

Highway cost allocation and subsequent analysis of revenue contribution should not be considered as a one-time exercise. Instead, it should be recognized as a part of a continuing process of pricing and financing highway services in Indiana. The 1988 update study indicated that a periodic updating of the cost responsibility and revenue contribution factors is essential in order to keep abreast with the changing traffic distributions, changing expenditure patterns, changing program emphasis, and changing technology.

APPENDIX A

DATA BASE

Traffic and Highway Mileage Data

The Planning Statistics Unit of IDOH conducts forty-eight hour counts on all sections of state roads in each of the ninety-two counties on a rotating schedule of about three years. In addition to state roads, some non-state rural and small urban road sections are also included. These counts are used to estimate annual average daily traffic volumes on the basis of appropriate seasonal adjustment factors. These sectional AADT values from 1984 to 1987 on state highway systems were used in this update study to compute vehicle-miles of travel. For the local highway system, a total of 317 county roads and 131 city street spot counts was used representing 54 counties with county roads and 35 counties with city streets for the years of 1986 and 1987. In addition to these traffic count data, the 1987 and 1988 portable/manual vehicle classification data collected by the IDOH at 307 stations were used to compute distribution of vehicle classes on the state highway system. For the distribution of vehicle classes on the local highway system, 22 stations were sampled. The sampled stations were carefully selected to cover the wide range of traffic volume on local roads and to represent population characteristics of 92 counties in Indiana. Vehicle classification data were then collected by IDOH at these selected stations during August, 1988. Additional data were necessary to obtain the following information:

1. relationship between registered weight and operating weight by vehicle class,

2. operating weight distributions of truck classes,

3. VMT percentages for various weight groups within different truck classes.

Related data were collected by the study team with a group of students at different weigh-stations in Indiana. The help of the Indiana State Police was obtained during the course of this study. Much of the additional data was collected at weigh-stations which were selected to represent wide variations of traffic within the state.

The 1988 Mileage Report from the Program Development Division of IDOH together with traffic count and vehicle classification data were used to estimate vehicle-miles of travel (VMT) by highway class and vehicle class. A detailed discussion of the estimation procedure is presented in Appendix B.

Cost Data

Cost data were collected separately for the state highway system, county roads and city streets. The information on FY 1988 state highway and bridge cost was provided by the IDOH. The cost figures of highways were shown separately as construction, rehabilitation and maintenance for Interstate, Primary and Secondary systems of state highways. Each of these costs was further subdivided into different items (for example, road work, design, R-O-W and relocation, miscellaneous, drainage, and so on). Bridge costs were also obtained for the three state highway systems as bridge construction, rehabilitation and maintenance. Like highways, bridge costs were further separated by different cost items. All of these costs are summarized in Part A of Table 5

of the report. Moreover, square feet of deck areas that were either reconstructed or built in 1988 for all three state highway systems by bridge structure type were provided by IDOH. Table A.1 summarizes the deck area data.

For the local road system, data on highway expenditure and revenue for all counties and 14 cities were extracted from annual reports and other data files located at the Purdue HERPICC offices. The information on total highway receipts and disbursements by fund category for countries and cities for several fiscal years was also available from the IDOH Planning and Budget Division. In addition, personal contacts were made with a group of county and city highway agencies to receive detailed cost data that were used to distribute the aggregated data collected from various sources. The distribution analysis was performed by grouping the available disaggregated data in categories of counties and cities of different population ranges. The estimated construction, rehabilitation and maintenance expenditures in cities and counties are summarized in Part B of Table 5 of this report.

Revenue Data

The data on state highway revenues were made available by the IDOH Planning and Budget Division for both state highway and local systems. The data included revenues according to their sources -- state gasoline tax, state special fuel tax, diesel surtax, MCFUT, vehicle license fees, IRP, oversize/overweight permits, and federal-aid. The breakdown of federal taxes was obtained from the FHWA. The local option tax information was collected from the Purdue HERPICC office.

Table A.1 Total Bridge Deck Area (sq. ft.) constructed in 1988 on State-Highway System

Bridge-Type	Interstate		State-Primary		State-Secondary	
	Built	Recons-tructed	Built	Recons-tructed	Built	Recons-tructed
Slab	73717	-	27600	31424	39740	1524
Box-Beam	-	-	5203	-	-	7738
I-Beam	-	-	2736	21770	14243	7846
Steel-Beam	732936	-	54984	212275	-	-
Steel-Girder	41015	-	122606	129875	17723	-

In addition to revenue data from Indiana Department of Highways the following agencies were also contacted to get more information on revenue data: Bureau of Motor Vehicles, Department of Revenue, and Federal Highway Administration (FHWA). Supplementary information was also used from the 1987 Highway Statistics, an annual report published by the FHWA.

APPENDIX B

ANALYSIS OF TRAFFIC DATA

One of the most critical data items necessary for a cost-allocation study is information on number of vehicle-miles traveled by each type of vehicles on each of the highway classes. An extensive county-by-county data collection program was undertaken by the IDOH as well as by the study team. In addition, input from a group of representatives from the trucking industry was also available. The procedure followed is discussed below.

Estimation of Vehicle Miles of Travel

The annual vehicle-miles of travel (VMT) in a year for a given highway section is simply the product of its traffic in that year and the section length in miles. When a highway section is shared by different vehicle classes, the VMT figures for individual classes measure the relative use of highway. In the present study, annual VMT figures for eleven vehicle classes were estimated for each of the six highway classes. A disaggregate approach was adopted to estimate the VMT. In this approach, VMT for each of the 92 counties of Indiana was calculated separately by highway class and by vehicle class and then summed to get the VMT values for the state. VMT values were estimated by using the following steps:

Step 1 - Highway Class Mileage: The mileages for each of the six highway classes - Interstate Urban, Interstate Rural, State Primary, State Secondary, County Road and City Street - were determined for each county from the 1988 mileage report of IDOH. The mileages for State Primary and Secondary highway

systems were further subdivided into the rural and urban mileages.

Step 2 - AADT of State Highway Sections: Average Annual Daily Traffic (AADT) values for all the sections of the state highway system - Interstate, Primary and Secondary - were available from 1987 Traffic Statistics of IDOH. The AADT values are estimated based on coverage counts made at all sections of the state highway system at every 3 to 4 years. The coverage counts are factored to AADT by using adjustment factors developed from continuous count station data. The sectional AADT values span over 1984 to 1987.

Step 3 - Highway Classification of Sections: All rural highway sections were identified into appropriate highway classes used in the study by following recent highway classification maps of each county available at the Joint Highway Research Project (JHRP) office. All state urban highway sections were classified by using Road Inventory File of IDOH.

Step 4 - 1988 County Average AADT Values: All state highway sectional AADT values were grouped according to rural and urban state highway classifications for each of the 92 counties. Then average AADT values for each county by rural and urban state highway classifications were determined. Separate average AADT values for rural and urban sections were calculated.

The average sectional AADT values for each county were adjusted to year 1988 by using aggregate growth factor models [Fricker and Saha 1987]. Growth factor (GF) models were developed by functional class of highways consisting of Interstate, Principal Arterial, Minor Arterial and Major Collector. In the analysis done in Step 3, it was observed that almost all principal arterial sections were primary sections, about 75% of minor arterial sections were

primary sections and almost all major collector sections were secondary routes. This information was used as a weight to determine the growth factors for the present study highway classes on the basis of the growth factors by functional class in each county.

Step 5 - 1988 VMT for State Highway Classes: Annual volumes were computed by multiplying 365 (no. of days in a year) with the 1988 county average AADT values from Step 4. The annual volumes were then multiplyed by highway section mileages from Step 1 to estimate annual VMT values for each of the three state highway classes for each county. For State Primary and State Secondary, urban and rural VMT values of each county were then combined. The statewide annual VMT for each highway class was then simply the sum of annual VMT from 92 counties.

Step 6 - VMT Distribution Among Vehicle Classes: The location of each of the 307 portable/manual vehicle classification stations on state highway system were identified according to the present study highway class by using the procedure discussed in Step 3. Then, all vehicle class observations were separated by highway class and by county. In case of more than one counting station on a particular highway class within a county, all counts were added together by vehicle class and then the percent distribution of vehicle classes was obtained. An estimate was made for those counties without any classification count stations within their jurisdictions. The estimate for interstates was made on the basis of vehicle class distributions from adjacent or closest counties. For primary and secondary highways, the estimation of vehicle class distribution for a county without any classification station data was made by comparing the county with counties of similar characteristics and with

classification station(s) within them. Population, licensed drivers, registered vehicles, annual VMT and percent of rural population were the county characteristics considered. Very few counties, however, needed estimated vehicle distributions.

Annual VMT for each vehicle class on a particular state highway system within a county was simply the product of vehicle class percentage distribution and annual total VMT for that highway class within the county resulted in Step 5. The state annual VMT for a particular vehicle class for a specific highway system was the sum of the results from 92 counties.

Step 7 - VMT for Local Highway Systems: Unlike the state highway system, traffic counts for local system were not available for all of the local highway sections. Traffic counts for 1986 and 1987 were received from IDOH for a total of 317 county road and 131 city street spots. After processing these raw counts, it was found that the counts represented 54 counties with county roads and 35 counties with city streets. The traffic count data were projected to 1988 AADT by using adjustment factors for seasonal and daily variations and major collector aggregate traffic growth factors [Fricker and Saha 1987]. Then, using Step 4, 1988 county Average AADT values were generated for 54 counties with county roads and 35 counties with city streets. For counties without any county road AADT and/or city street AADT, the required AADT values were estimated by matching these counties with the counties for which traffic counts were available. The matching was based on the population of city or county, mileage of county roads or city streets, number of county vehicle registrations, number of county households and similarity of geographic regions.

For vehicle class distribution, 22 count stations were selected representing the fairly wide range of variations of county and city population. Vehicle classification counts were collected at these stations during August, 1988. The estimates of vehicle class distributions for the remaining counties were based upon as many similar counties as possible. The results of this assumption showed that most counties had similar distributions. This was particularly true for small counties (there are 69 small counties, 19 medium sized and 4 large).

The total annual and percent VMT values for six highway classes for 1988 together with the corresponding values for 1983 study are given in Table B.1. The results of 1988 VMT values were checked by comparing the total values with those obtained from highway fuel use data. It can be noted that there was approximately an increase of 17.4% in VMT in 1988 since 1983. But the percent distributions of VMT among the highway functional classes remained stable. The 1988 VMT values by highway and vehicle classes are shown in Table B.2. In 1988 the VMT by passenger car, bus, single unit truck and combination truck on Indiana highway system were 88.42, 0.57, 3.26 and 7.75 percent, respectively. Tables B.3 through B.8 show the 1988 percent VMT values computed for the eleven vehicle classes and the constituent weight subgroups.

Correspondence Matrices for Registered and Operating Weight Groups

While the cost responsibility analysis was based upon gross operating weights of vehicles, truck registration fees are collected according to maximum gross registered weights. For the purpose of distributing revenues to

Table B.1 Indiana Highway VMT Values by Highway Functional Class

Highway Functional Class	1983 VMT (*)	1985-86 VMT (*)	1988 VMT
1 Interstate Urban	3,648,196,397 9.42%	3,756,549,624 9.43%	4,572,250,242 10.05%
2 Interstate Rural	4,403,050,390 11.36%	4,548,825,803 11.41%	5,134,060,391 11.29%
3 State Route Primary	7,895,474,051 20.38%	8,120,381,844 20.37%	9,602,005,590 21.11%
4 State Route Secondary	5,406,210,594 13.95%	5,556,036,215 13.94%	6,085,929,408 13.38%
5 County Road	6,038,969,997 15.59%	6,202,652,957 15.56%	6,882,168,967 15.13%
6 City Street	11,354,525,755 29.30%	11,671,149,284 29.28%	13,214,335,539 29.05%
Total	38,746,427,184 100.00%	39,855,595,727 100.00%	45,490,750,137 100.00%

(*) Source: Indiana Highway Cost Allocation Study: Final Report, FHWA/IN/JHRP-84/20, Table B.15, pp 75

Table B.2 1988 VMT Values by Highway Functional Class and by Vehicle Class

Functional Class	VMT	Vehicle Class (1)	(2)	(3)	(4)
1 Interstate	Percent	30.269%	52.081%	2.108%	0.183%
Urban	Annual	1383971576	2381282785	96376930	8373972
2 Interstate	Percent	24.868%	42.788%	1.763%	0.592%
Rural	Annual	1276729768	2196760881	90532997	30380390
3 State Route	Percent	31.358%	53.955%	2.429%	0.821%
Primary	Annual	3011013988	5180796991	233220016	78842914
4 State Route	Percent	32.968%	56.725%	2.716%	0.978%
Secondary	Annual	2006403560	3452248833	165293291	59538236
5 County Road	Percent	35.322%	60.775%	1.856%	0.612%
	Annual	2430888193	41826236624	127762491	42124388
6 City Street	Percent	35.378%	60.873%	1.192%	0.313%
	Annual	4675013116	8043899490	157568639	41424527
Total	Percent	32.50%	55.92%	1.91%	0.57%
	Annual	14784020201	25437612604	870754364	260684427

Functional Class	VMT	Vehicle Class (5)	(6)	(7)	(8)
1 Interstate	Percent	0.840%	0.310%	1.629%	11.654%
Urban	Annual	38392935	14156576	74462163	532830467
2 Interstate	Percent	1.273%	1.138%	2.995%	21.192%
Rural	Annual	65376951	58442271	153772708	1087962863
3 State Route	Percent	1.161%	0.456%	1.894%	6.920%
Primary	Annual	111465108	43797546	181816645	664472751
4 State Route	Percent	1.371%	0.177%	1.536%	3.215%
Secondary	Annual	83432967	10798743	93455818	195662138
5 County Road	Percent	0.502%	0.075%	0.450%	0.409%
	Annual	34519905	5140535	30963145	28146686
6 City Street	Percent	0.936%	0.176%	0.434%	0.472%
	Annual	123743833	23242481	57322941	62323734
Total	Percent	1.00%	0.34%	1.30%	5.65%
	Annual	456931699	155578152	591793420	2571398639

Table B.2 1988 VMT Values by Highway Functional Class and by Vehicle Class (continued)

Functional Class	VMT	Vehicle Class (9)	(10)	(11)	Total
1 Interstate	Percent	0.568%	0.291%	0.068%	10.05%
Urban	Annual	25964224	13324548	3114066	4572250242
2 Interstate	Percent	1.061%	2.091%	0.239%	11.29%
Rural	Annual	54486552	107360227	12254783	5134060391
3 State Route	Percent	0.163%	0.804%	0.039%	21.11%
Primary	Annual	15663154	77211464	3705013	9602005590
4 State Route	Percent	0.029%	0.281%	0.003%	13.38%
Secondary	Annual	1776939	17108904	209979	6085929408
5 County Road	Percent	0.000%	0.000%	0.000%	15.13%
	Annual	0	0	0	6882168967
6 City Street	Percent	0.004%	0.070%	0.151%	29.05%
	Annual	576990	9260358	19959430	13214335539
Total	Percent	0.22%	0.49%	0.09%	100.00%
	Annual	98467859	224265501	39243271	45490750137

SUMMARY RESULTS:

	VMT	Percent-VMT
Passanger Car:	40,221,632,805	88.42%
Bus:	260,684,427	0.57%
SU Truck:	1,483,264,215	3.26%
Combination Truck:	3,525,168,690	7.75%
Total:	45,490,750,137	100.00%

Table B.3 Percent VMT of Vehicle Classes on Urban Interstate (1988)

Veh Class	Sub-Group	Vehicle-Mile % Veh Class	Sub-group
1	1	30.269	30.269
2	1	52.081	52.081
3	1	2.108	0.048
3	2		0.160
3	3		0.192
3	4		0.543
3	5		0.415
3	6		0.303
3	7		0.160
3	8		0.128
3	9		0.160
4	1	0.183	0.183
5	1	0.840	0.102
5	2		0.051
5	3		0.076
5	4		0.153
5	5		0.127
5	6		0.127
5	7		0.076
5	8		0.076
5	9		0.051
6	1	0.310	0.155
6	2		0.155
7	1	1.629	0.033
7	2		0.064
7	3		0.235
7	4		0.106
7	5		0.192
7	6		0.150
7	7		0.127
7	8		0.117
7	9		0.138
7	10		0.127
7	11		0.127
7	12		0.117
7	13		0.096
8	1	11.654	0.023
8	2		0.117
8	3		0.404
8	4		1.138
8	5		0.921
8	6		0.571
8	7		0.478
8	8		0.420
8	9		0.385
8	10		0.354
8	11		0.343
8	12		0.330
8	13		0.291
8	14		0.343
8	15		0.373
8	16		0.473
8	17		0.420
8	18		0.396
8	19		0.967
8	20		1.025
8	21		0.443
8	22		0.641
8	23		0.501
8	24		0.237
8	25		0.019
8	26		0.043
9	1	0.568	0.066
9	2		0.109
9	3		0.022
9	4		0.044
9	5		0.022
9	6		0.022
9	7		0.044
9	8		0.065
9	9		0.065
9	10		0.044
9	11		0.022
9	12		0.022
9	13		0.022
10	1	0.291	0.073
10	2		0.109
10	3		0.109
11	1	0.068	0.023
11	2		0.023
11	3		0.023

Table B.4 Percent VMT of Vehicle Classes on Rural Interstate (1988)

Veh Class	Sub-Group	Vehicle-Mile % Veh Class	Vehicle-Mile % Sub-group
1	1	24.868	24.868
2	1	42.788	42.788
3	1	1.763	0.040
3	2		0.134
3	3		0.160
3	4		0.454
3	5		0.347
3	6		0.254
3	7		0.134
3	8		0.107
3	9		0.134
4	1	0.592	0.592
5	1	1.273	0.154
5	2		0.077
5	3		0.116
5	4		0.232
5	5		0.193
5	6		0.193
5	7		0.116
5	8		0.116
5	9		0.077
6	1	1.138	0.569
6	2		0.569
7	1	2.995	0.060
7	2		0.117
7	3		0.431
7	4		0.195
7	5		0.353
7	6		0.276
7	7		0.234
7	8		0.216
7	9		0.255
7	10		0.234
7	11		0.234
7	12		0.216
7	13		0.177
8	1	21.192	0.042
8	2		0.212
8	3		0.735
8	4		2.070
8	5		1.674
8	6		1.038
8	7		0.869
8	8		0.763
8	9		0.699
8	10		0.644
8	11		0.623
8	12		0.600
8	13		0.530
8	14		0.623
8	15		0.678
8	16		0.860
8	17		0.763
8	18		0.720
8	19		1.759
8	20		1.865
8	21		0.805
8	22		1.165
8	23		0.911
8	24		0.430
8	25		0.034
8	26		0.078
9	1	1.061	0.123
9	2		0.204
9	3		0.041
9	4		0.082
9	5		0.041
9	6		0.041
9	7		0.082
9	8		0.122
9	9		0.122
9	10		0.082
9	11		0.041
9	12		0.041
9	13		0.041
10	1	2.091	0.523
10	2		0.784
10	3		0.784
11	1	0.239	0.080
11	2		0.080
11	3		0.080

Table B.5 Percent VMT of Vehicle Classes on State Primary Roads (1988)

Veh Class	Sub-Group	Vehicle-Mile % Veh Class	Vehicle-Mile % Sub-group
1	1	31.358	31.358
2	1	53.955	53.955
3	1	2.429	0.140
3	2		0.373
3	3		0.373
3	4		0.515
3	5		0.420
3	6		0.233
3	7		0.141
3	8		0.141
3	9		0.092
4	1	0.821	0.821
5	1	1.161	0.406
5	2		0.174
5	3		0.232
5	4		0.174
5	5		0.029
5	6		0.029
5	7		0.038
5	8		0.038
5	9		0.039
6	1	0.456	0.064
6	2		0.392
7	1	1.894	0.119
7	2		0.295
7	3		0.474
7	4		0.356
7	5		0.237
7	6		0.237
7	7		0.028
7	8		0.030
7	9		0.028
7	10		0.030
7	11		0.019
7	12		0.019
7	13		0.021
8	1	6.920	0.021
8	2		0.150
8	3		0.696
8	4		0.906
8	5		0.549
8	6		0.335
8	7		0.211
8	8		0.228
8	9		0.171
8	10		0.190
8	11		0.235
8	12		0.171
8	13		0.171
8	14		0.464
8	15		0.378
8	16		0.464
8	17		0.314
8	18		0.335
8	19		0.232
8	20		0.000
8	21		0.253
8	22		0.171
8	23		0.211
8	24		0.021
8	25		0.021
8	26		0.021
9	1	0.163	0.049
9	2		0.033
9	3		0.024
9	4		0.016
9	5		0.008
9	6		0.008
9	7		0.008
9	8		0.003
9	9		0.003
9	10		0.003
9	11		0.003
9	12		0.002
9	13		0.002
10	1	0.804	0.268
10	2		0.268
10	3		0.268
11	1	0.039	0.013
11	2		0.013
11	3		0.013

Table B.6 Percent VMT of Vehicle Classes on State Secondary Roads (1988)

Veh Class	Sub-Group	Vehicle-Mile % Veh Class	Vehicle-Mile % Sub-group
1	1	32.968	32.968
2	1	56.725	56.725
3	1	2.716	0.746
3	2		0.266
3	3		0.746
3	4		0.426
3	5		0.106
3	6		0.266
3	7		0.106
3	8		0.027
3	9		0.027
4	1	0.978	0.978
5	1	1.371	0.480
5	2		0.343
5	3		0.137
5	4		0.137
5	5		0.034
5	6		0.034
5	7		0.034
5	8		0.034
5	9		0.137
6	1	0.177	0.000
6	2		0.177
7	1	1.536	0.209
7	2		0.209
7	3		0.279
7	4		0.140
7	5		0.071
7	6		0.279
7	7		0.069
7	8		0.069
7	9		0.035
7	10		0.035
7	11		0.035
7	12		0.035
7	13		0.070
8	1	3.215	0.022
8	2		0.045
8	3		0.134
8	4		0.604
8	5		0.244
8	6		0.244
8	7		0.134
8	8		0.244
8	9		0.201
8	10		0.180
8	11		0.199
8	12		0.067
8	13		0.090
8	14		0.067
8	15		0.067
8	16		0.045
8	17		0.067
8	18		0.134
8	19		0.111
8	20		0.045
8	21		0.090
8	22		0.134
8	23		0.022
8	24		0.016
8	25		0.003
8	26		0.003
9	1	0.029	0.009
9	2		0.009
9	3		0.006
9	4		0.003
9	5		0.003
9	6		0.000
9	7		0.000
9	8		0.000
9	9		0.000
9	10		0.000
9	11		0.000
9	12		0.000
9	13		0.000
10	1	0.281	0.094
10	2		0.094
10	3		0.094
11	1	0.003	0.001
11	2		0.001
11	3		0.001

Table B.7 Percent VMT of Vehicle Classes on County Roads (1988)

Veh Class	Sub-Group	Vehicle-Mile % Veh Class	Vehicle-Mile % Sub-group
1	1	35.322	35.322
2	1	60.775	60.775
3	1	1.856	0.509
3	2		0.182
3	3		0.509
3	4		0.291
3	5		0.072
3	6		0.182
3	7		0.072
3	8		0.019
3	9		0.019
4	1	0.612	0.612
5	1	0.502	0.176
5	2		0.125
5	3		0.050
5	4		0.050
5	5		0.013
5	6		0.013
5	7		0.013
5	8		0.013
5	9		0.050
6	1	0.075	0.000
6	2		0.075
7	1	0.450	0.061
7	2		0.061
7	3		0.082
7	4		0.041
7	5		0.021
7	6		0.082
7	7		0.020
7	8		0.020
7	9		0.010
7	10		0.010
7	11		0.010
7	12		0.010
7	13		0.020
8	1	0.409	0.003
8	2		0.017
8	3		0.017
8	4		0.077
8	5		0.017
8	6		0.031
8	7		0.017
8	8		0.011
8	9		0.026
8	10		0.023
8	11		0.006
8	12		0.009
8	13		0.011
8	14		0.009
8	15		0.009
8	16		0.006
8	17		0.009
8	18		0.031
8	19		0.014
8	20		0.025
8	21		0.031
8	22		0.006
8	23		0.003
8	24		0.003
8	25		0.000
8	26		0.000
9	1	0.000	0.000
9	2		0.000
9	3		0.000
9	4		0.000
9	5		0.000
9	6		0.000
9	7		0.000
9	8		0.000
9	9		0.000
9	10		0.000
9	11		0.000
9	12		0.000
9	13		0.000
10	1	0.000	0.000
10	2		0.000
10	3		0.000
11	1	0.000	0.000
11	2		0.000
11	3		0.000

Table B.8 Percent VMT of Vehicle Classes on City Streets (1988)

Veh Class	Sub-Group	Vehicle-Mile % Veh Class	Vehicle-Mile % Sub-group
1	1	35.378	35.378
2	1	60.873	60.873
3	1	1.192	0.327
3	2		0.117
3	3		0.327
3	4		0.187
3	5		0.046
3	6		0.117
3	7		0.046
3	8		0.012
3	9		0.012
4	1	0.313	0.313
5	1	0.936	0.328
5	2		0.234
5	3		0.094
5	4		0.094
5	5		0.023
5	6		0.023
5	7		0.023
5	8		0.023
5	9		0.094
6	1	0.176	0.000
6	2		0.176
7	1	0.434	0.059
7	2		0.059
7	3		0.079
7	4		0.039
7	5		0.020
7	6		0.079
7	7		0.020
7	8		0.020
7	9		0.010
7	10		0.010
7	11		0.010
7	12		0.010
7	13		0.020
8	1	0.472	0.003
8	2		0.020
8	3		0.020
8	4		0.089
8	5		0.020
8	6		0.036
8	7		0.020
8	8		0.013
8	9		0.029
8	10		0.026
8	11		0.007
8	12		0.010
8	13		0.013
8	14		0.010
8	15		0.010
8	16		0.007
8	17		0.010
8	18		0.036
8	19		0.016
8	20		0.029
8	21		0.036
8	22		0.007
8	23		0.003
8	24		0.002
8	25		0.000
8	26		0.000
9	1	0.000	0.000
9	2		0.000
9	3		0.000
9	4		0.000
9	5		0.000
9	6		0.000
9	7		0.000
9	8		0.000
9	9		0.000
9	10		0.000
9	11		0.000
9	12		0.000
9	13		0.000
10	1	0.070	0.023
10	2		0.023
10	3		0.023
11	1	0.151	0.050
11	2		0.050
11	3		0.050

appropriate vehicle classes and weight groups considered in the study, a series of correspondence matrices were developed to relate registered vehicle weight classes to operating weight classes. The matrices are presented in Tables B.9 through B.16. Several sources were used to obtain data for establishing these correspondence matrices. First, the truck data collected during the course of this study were used. In addition, an extensive truck data base was available from the recently completed weigh-in-motion study. This data base provided the much needed data for non-Interstate highways. The input from a group of representatives from the trucking industry on operating weight distribution by highway class was also incorporated in the analysis.

Table B.9 Vehicle Registration Weight-Operating Weight Correspondence Matrix for Single-Unit Truck Class 3

Registration	Operating Weight Group Percentages								
Weight (lbs)	1	2	3	4	5	6	7	8	9
<9000	67	28	4	1					
9000-10999	39	33	20	6	2				
11000-15999	20	40	20	10	9	1			
16000-19999	15	29	10	7	7	4	3		
20000-25999	6	10	20	22	18	13	7	3	1
>26000	5	9	14	27	23	10	7	3	2

Table B.10 Vehicle Registration Weight-Operating Weight Correspondence Matrix for Single-Unit Truck Class 5

Registration Weight (lbs)	Operating Weight Group Percentages								
	1	2	3	4	5	6	7	8	9
<9000-10999	100								
9000-10999	90	10							
11000-15999	75	20	5						
16000-19999	60	25	13	2					
20000-25999	50	16	14	10	6	4			
26000-29999	35	12	14	11	10	9	7	2	
30000-35999	20	12	14	16	12	10	10	6	
>36000	10	10	15	18	15	13	10	7	2

Table B.11 Vehicle Registration Weight-Operating Weight Correspondence Matrix for Single-Unit Truck Class 6

Registration	Operating Weight Group Percentages							
Weight (lbs)	1	2	3	4	5	6	7	8
<20000	80	20						
20000-25999	60	40						
26000-29999	40	60						
30000-35999	30	70						
36000-41999	20	80						
42000-47999	10	90						
48000-53000	5	95						
>54000		100						

Table B.12 Vehicle Registration Weight-Operating Weight

Correspondence Matrix for Combination Truck Class 7

Registration	Operating Weight Group Percentages												
Weight (lbs)	1	2	3	4	5	6	7	8	9	10	11	12	13
<26000	60	20	15	5									
26000-29999	30	20	20	15	10	5							
30000-35000	10	10	15	20	17	15	10	3					
36000-41999	6	6	9	12	15	15	15	11	8	3			
42000-47999	5	5	7	10	14	14	15	10	8	8	3	1	
48000-53999	4	5	6	10	14	14	15	10	9	8	3	2	
>54000	3	5	6	8	9	12	14	14	14	6	4	4	2

Table B.13 Vehicle Registration Weight-Operating Weight

Correspondence Matrix for Combination Truck Class 8

Registration	Operating Weight Group Percentages												
Weight (lbs)	1	2	3	4	5	6	7	8	9	10	11	12	13
<26000	45	30	20	5									
26000-29999	25	20	20	15	10	5	5						
30000-35999	10	10	15	20	17	15	10	3					
36000-41999	3	6	9	12	15	15	15	11	8	6			
42000-47999	2	4	5	7	8	9	12	10	10	10	10	7	3
48000-53999	1	2	5	8	8	7	6	6	6	8	8	8	8
54000-59999	1	2	5	8	8	7	6	6	6	6	6	6	6
60000-65999		1	3	8	8	5	5	5	5	5	5	4	4
66000-71999		1	2	8	7	5	5	5	5	5	5	3	2
72000-73999		1	2	8	7	6	5	5	5	4	4	3	2
74000-75999			1	7	8	5	5	5	5	5	3	3	2
76000-77999			1	7	8	5	5	5	5	5	3	3	2
>78000			1	7	8	5	5	5	5	5	3	3	2

Table B.13 (Continued).

Registration Weight (lbs)	Operating Weight Group Percentages												
	14	15	16	17	18	19	20	21	22	23	24	25	26
20000-25999													
26000-29999													
30000-35999													
36000-41999													
42000-47999	2	1											
48000-53999	9	6	3	1									
54000-59999	5	8	8	3	3								
60000-65999	4	4	8	8	6	6	4	2					
66000-71999	2	2	3	6	8	8	7	5	4	2			
72000-73999	2	2	2	2	8	8	8	6	4	4	2		
74000-75999	2	2	2	2	3	8	8	6	6	6	4	1	1
76000-77999	2	2	2	2	3	8	8	6	6	6	4	1	1
≥78000	2	2	2	2	3	8	8	6	6	6	4	1	1

Table B.14 Vehicle Registration Weight-Operating Weight Correspondence Matrix for Combination Truck Class 9.

Registration Weight (lbs)	Operating Weight Group Percentages												
	1	2	3	4	5	6	7	8	9	10	11	12	13
<26000	100												
26000-29999	100												
30000-35999	100												
36000-41999	85	10	5										
42000-47999	65	13	12	7	3								
48000-53999	45	12	10	10	8	7	5	3					
54000-59999	30	8	10	10	8	8	8	8	6	4			
60000-65999	25	5	5	9	9	9	7	7	6	6	5	4	3
66000-71999	20	4	6	10	10	8	8	7	6	6	6	5	4
>72000	20	3	6	10	10	8	8	7	6	6	6	5	5

Table B.15 Vehicle Registration Weight-Operating Weight Correspondence Matrix for Combination Truck Class 10.

Registration Weight (lbs)	Operating Weight Group Percentages												
	1	2	3	4	5	6	7	8	9	10	11	12	13
<30000	100												
30000-35999	95	5											
36000-41999	90	10											
42000-47999	70	30											
48000-53999	65	35											
54000-59999	55	45											
60000-65999	45	45	10										
66000-71999	40	48	12										
>72000	35	50	15										

Table B.16 Vehicle Registration Weight-Operating Weight Correspondence Matrix for Combination Truck Class 11.

Registration Weight (lbs)	Operating Weight Group Percentages												
	1	2	3	4	5	6	7	8	9	10	11	12	13
<30000	100												
30000-35999	95	5											
36000-41999	90	10											
42000-47999	70	30											
48000-53999	65	35											
54000-59999	55	45											
60000-65999	45	45	10										
66000-71999	40	48	12										
>72000	35	50	15										

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